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THESIS

LOGISTICAL IMPLICATIONS
OF
OPERATIONAL MANEUVER FROM THE SEA

by

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March, 1997

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This thesis determines the distance from the coastline sea-based Combat Service Support (CSS) assets will be able to maintain and still support operations of a given magnitude, and how tactically constrained Navy ships will be in order to support this concept of expeditionary warfare. It focuses on the time-distance-weight/volume relationships involved, and takes into account characteristics of the resupply assets, such as aircraft availability, capacity, method of employment, and the effects of combat attrition. Three methods of employing a Marine Expeditionary Unit are studied, ranging from a traditional force mix to the use of small infestation teams. The analysis shows that the available CSS assets will not support a traditional ground force mix at the distances envisioned, but will support the use of small teams. To fully realize OMFTS and still allow ships to maintain the desired standoff from shore will require a shift to more lethal Marine forces with much smaller logistical demands. Until such a force is feasible, the Navy should plan on providing support to Marines from close to shore.

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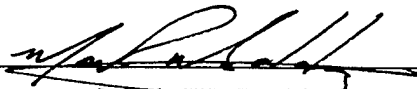of the requirements for the degree of

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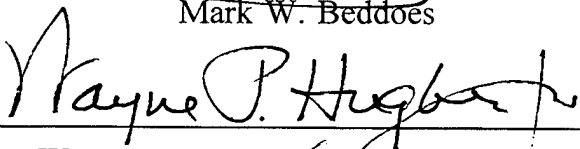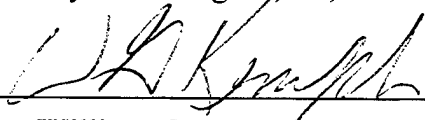from the

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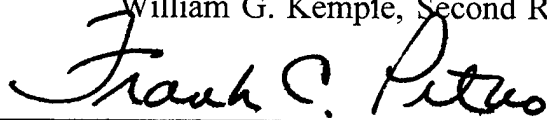### March, 1997

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ABSTRACT

The U.S. Marine Corps concept for the projection of naval power ashore is *Operational Maneuver From the Sea* (OMFTS). OMFTS calls for movement of Marines from ships at sea directly to objectives deep inland without requiring a pause to build-up combat power on the beach. Support for ground forces is expected to come from the sea, and be delivered primarily by air. This demands that sea-based logistics assets remain sufficiently close to shore to allow air assets to conduct resupply operations directly to the battlefield. The implication of this is that Navy ships may sacrifice operational and perhaps tactical mobility while sustaining the Marine operation.

This thesis determines the distance from the coastline sea-based Combat Service Support (CSS) assets will be able to maintain and still support operations of a given magnitude, and how tactically constrained Navy ships will be in order to support this concept of expeditionary warfare. It focuses on the time-distance-weight/volume relationships involved, and takes into account characteristics of the resupply assets, such as aircraft availability, capacity, method of employment, and the effects of combat attrition. Three methods of employing a Marine Expeditionary Unit are studied, ranging from a traditional force mix to the use of small infestation teams. The analysis shows that the available CSS assets will not support a traditional ground force mix at the distances envisioned, but will support the use of small teams. To fully realize OMFTS and still allow ships to maintain the desired standoff from shore will require a shift to more lethal Marine forces with much smaller logistical demands. Until such a force is feasible, the Navy should plan on providing support to Marines from close to shore.

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EXECUTIVE SUMMARY

The U.S. Marine Corps concept for the projection of naval power ashore is *Operational Maneuver From the Sea* (OMFTS). Like *Forward ... From the Sea*, it emphasizes the world's littoral regions as areas for potential conflict, and the role of the Naval Expeditionary Force (NEF) in those conflicts. The availability of inexpensive advanced weapons and sensors to potential adversaries will make traditional amphibious methods of ship-to-shore movement and lodgement ashore more risky. To reduce this vulnerability, OMFTS calls for movement from ships at sea directly to objectives inland without requiring a pause to build up at a beachhead. To accomplish this, assault forces must be lighter and faster, and a great deal of command, control, communications, computers, intelligence (C4I), combat service support (CSS), and fire support (Naval Surface Fire Support and Close Air Support) must be sea-based.

The U.S. Marine Corps Commandant's Warfighting Laboratory was established in October, 1995 to develop and test advanced technologies and operational concepts to support OMFTS. The developmental process is known as *Sea Dragon*. One of the concepts under development envisions small, highly mobile teams dispersed over a battlefield up to 200 x 200 nautical miles in size. These teams would infest an area, identify critical targets, and engage selected targets by calling in precision fires. The desired capability is to achieve the combat power of a large force spread over the entire battlefield while not presenting a large, fixed target to retaliate against. Major support for these units, in the form of command and coordination, fires, and sustainment, will all remain at sea.

One of OMFTS's goals is to reduce the buildup of forces and equipment ashore. Delivery and sustainment of ground forces is expected to come directly from the sea, primarily by air. This demands that sea-based logistics assets remain sufficiently close to shore to allow air assets to conduct resupply operations directly to the battlefield. One implication of this is that Navy ships may have to sacrifice operational and perhaps tactical mobility to sustain the Marine operation.

The thesis determines the distance from the coastline that sea-based CSS assets will be able to maintain and still support MEU-sized OMFTS operations using either traditional

forces or small infestation teams. It focuses on the time-distance-weight/volume relationships involved in the delivery and sustainment of forces ashore, and takes into account characteristics of the resupply assets, such as aircraft availability and capacity, and the effects of attrition. The objective is to provide pragmatic quantitative estimates as to how tactically constrained the Navy ships will be while supporting this new form of expeditionary warfare under a wide variety of circumstances.

OMFTS, as envisioned, precludes surface resupply. Surface resupply over land requires secure land lines of communication and ground transportation. The distances involved require defense of these lines of communication, just as a beach CSS area would. CSS must be provided by air. This thesis measures the outer limits of airborne CSS of a MEU(SOC) based on the airlift assets in a future MEU as it is now planned.

The analysis shows that when OMFTS is conducted using traditional forces, the envisioned amphibious ship standoff of 50+ NM is difficult, and is not possible in a non-permissive air environment. Shifting to a non-mechanized force does not ease the problem because of the increased airborne troop movement requirements. Shifting to the use of infestation teams helps somewhat. However, the current practice of sending a two-aircraft section severely limits the possible range capability, because their payload is so light. If only one aircraft is sent to resupply or move a team, there is a huge increase in range. Increased capability could be achieved by a number of different measures, such as increasing the number of aircrews, increasing the number of aircraft, reducing the number of aircraft used per mission, and exploiting the combat power of an accompanying carrier battle group.

To realize the full value of OMFTS, there must be a shift to more lethal forces with smaller logistical demands, or a sizable increase in airlift capability. To maintain a safe standoff from shore, maintain operational flexibility, and still support OMFTS, the Navy will need to push development of inshore combat tactics through means similar to those undertaken by the Commandant's Warfighting Lab. Influencing events ashore is more than being able to strike deep inland with precision weapons and aircraft. It is the ability to affect the campaign deep inland with forces on the ground. Until a lighter, more lethal Marine force is feasible, the Navy should plan on providing support to Marines from close to shore.

I. INTRODUCTION

A campaign plan that cannot be logistically supported is not a plan at all, but simply an expression of fanciful wishes. John F. Meehan III (Meehan, 1993).

And it ought to be remembered that there is nothing more difficult to take in hand, more perilous to conduct, or more uncertain in its success, than to take the lead in the introduction of a new order of things. Because the innovator has for enemies all those who have done well under the old conditions, and lukewarm defenders in those who may do well under the new. This coolness arises partly from fear of the opponents, who have the laws on their side, and partly from the incredulity of men, who do not readily believe in new things until they have had a long experience of them. Nicollo Machiavelli (Machiavelli).

A. OBJECTIVE OF THESIS

The U.S. Marine Corps concept for the projection of naval power ashore is *Operational Maneuver From the Sea* (OMFTS). Like *Forward ... From the Sea*, it emphasizes the world's littoral regions as areas for potential conflict, and the role of the Naval Expeditionary Force (NEF) in those conflicts. The availability of inexpensive advanced weapons and sensors to potential adversaries will make traditional amphibious methods of ship-to-shore movement and lodgement ashore more risky. To reduce this vulnerability, OMFTS calls for movement from ships at sea directly to objectives inland without requiring a pause to build up at a beachhead. To accomplish this, assault forces must be lighter and faster, and a great deal of command, control, communications, computers, intelligence (C4I), combat service support (CSS), and fire support (Naval Surface Fire Support and Close Air Support) must be sea-based (U.S. Marine Corps, 1996).

The U.S. Marine Corps Commandant's Warfighting Laboratory was established in October, 1995 to develop and test advanced technologies and operational concepts to support OMFTS. The developmental process is known as *Sea Dragon*. One of the concepts under development envisions small, highly mobile teams dispersed over a battlefield up to 200 x 200 nautical miles in size. These teams are referred to by several different names. One that is commonly used is reconnaissance assault platoons (RAPs), and this will be used in this thesis. The RAPs would infest an area, identify critical targets, and engage selected targets by calling in precision fires. The desired capability is to achieve the combat power of a large

1

force spread over the entire battlefield while not presenting a large, fixed target to retaliate against. Major support for these units, in the form of command and coordination, fires, and sustainment, will all remain at sea (Commandant's Warfighting Laboratory, 1997).

One of OMFTS's goals is to reduce the buildup of forces and equipment ashore. Delivery and sustainment of ground forces is expected to come directly from the sea, primarily by air. This demands that sea-based logistics assets remain sufficiently close to shore to allow air assets (CH-53E, MV-22) to conduct resupply operations directly to the battlefield. One implication of this is that Navy ships may have to sacrifice operational and perhaps tactical mobility to sustain the Marine operation.

The thesis will determine the distance from the coastline that sea-based CSS assets will be able to maintain and still support MEU-sized OMFTS operations using either traditional forces or RAPs. It will not explore the validity of the RAP concept itself, or the other issues (prominently C4I and fire support) involved with its employment. The thesis will focus on the time-distance-weight/volume relationships involved in the delivery and sustainment of forces ashore. It will take into account characteristics of the resupply assets, such as aircraft availability and capacity, and the effects of attrition. The objective of this thesis is to provide pragmatic quantitative estimates as to how tactically constrained the Navy ships will be while supporting this new form of expeditionary warfare under a wide variety of circumstances.

It must be remembered that the Marine Corps will continue to be prepared to conduct traditional amphibious operations, Sustained Operations Ashore (SOA), and Operations Other than War (OOTW), as well as Operational Maneuver from the Sea. But, some forms of OMFTS are drastic departures from traditional operations in the demands placed on logistics, C4I, and fire support in return for the greatly expanded area of influence of a Marine Air-Ground Task Force (MAGTF). For this reason, OMFTS is the focus of this thesis.

B.   SHIP TO OBJECTIVE MANEUVER (STOM)

Traditional amphibious maneuver from the sea is a three-step process: (1) maneuver in ships; (2) transition ashore; (3) maneuver ashore. Step (1) allows much more flexible

positioning of forces than can be achieved by forces ashore. While the defending forces must cover all possible avenues of entry, the sea-borne forces may choose when and where to attack. Step (2) is the movement of land combat units ashore, and requires an assault to secure a lodgement on the beach from which to execute step (3). The time required to complete step (2) often offsets the advantage gained by step (1). By the time sufficient combat power is on the beach, a support area secured, and units are ready to commence maneuver on land, the enemy often will have had time to prepare a defense or counter attack (Lyons and Magwood, 1994). OMFTS, using STOM, seeks to eliminate step (2), the transition ashore. This will be made possible by technological advances in mobility as well as advances in fire support and C4I.

> The goal of Ship-to-Objective Maneuver is to apply the principles and tactics of modern land maneuver to amphibious battlefields. Specifically, we will conduct combined arms penetration and exploitation operations from over the horizon at sea directly to the accomplishment of objectives ashore, without stopping to seize, defend, and build up beaches, landing zones, or other penetration points (U.S. Marine Corps, 1995).

C.   SEA DRAGON

Sea Dragon is the development process for new, high-risk concepts to support OMFTS. The Commandant's Warfighting Laboratory (CWL) is tasked with field testing advanced technologies and concepts in order to identify those with promise as well as those that should be pursued no further at present. One of the concepts to emerge from this process is the use of light, dispersed, foot mobile teams empowered with advanced C4I and remote, on-call fire support to engage an adversary indirectly. The intent is to provide the massed weapons effects of a large force while not presenting a massed target. These units have very little combat power of their own, and rely on improved, timely fire support more than do traditionally organized units executing STOM. The dispersion and size of these units require that they be stealthy and mobile in order to survive and be effective. This requirement for speed and stealthiness also applies to their means of delivery and support. The CWL is exploring resupply methods that will enable an aircraft to deliver support

without compromising the location of the supported units (Commandant's Warfighting Laboratory, 1997).

D.   NAVY LITTORAL CONSIDERATIONS

OMFTS requires C4I/fires/logistics to be based at sea to the maximum extent possible. Thus, Navy vessels must remain close enough to supply the just-in-time support entailed. This task is complicated by dangers associated with the littorals:

- Mines. The inability to rapidly detect and clear mines forces ships to remain further away from shore.

- Anti-ship missiles (ASMs). Low-observable, high speed ASMs leave a very small time window in which to defend. Even with Cooperative Engagement Capability (CEC), depth of fire is required for safety.

- Diesel submarines. These operate close to shore, and shallow-water antisubmarine warfare (ASW) is difficult.

- Small coastal craft. The U.S. Navy is comprised of blue water warships and is not well suited for defending against small craft.

Traditional amphibious operations require amphibious shipping to approach within 10,000 yards of the beach. STOM envisions a minimum standoff of 25 NM for deployment of AAAVs, 40 NM for LCAC operations, and 50 NM or greater for aircraft operations (U.S. Marine Corps, 1995). Ideally, capital ships (CVN, LHD/LHA, and Arsenal ship) would remain more than 100 NM from shore.

II. ASSUMPTIONS AND METHODOLOGY

A.   SCOPE OF THE PROBLEM

This analysis is limited to a Marine Expeditionary Unit, Special Operations Capable (MEU(SOC)) Marine force, the Navy ships and aircraft present in a typical Amphibious Ready Group (ARG), and a 15-day duration of operations with no external support. Only the logistical aspects (Combat Service Support) of OMFTS are considered. The required advances in C4I and fire support have not yet been achieved, but a sufficient capability is assumed for the time frame of this study, 2010-2015.

Combat Service Support has six functional areas: Supply, Maintenance, Transportation, General Engineering, Health Services, and Other Services (U.S. Marine Corps, 1993). This analysis is concerned primarily with the supply and transportation functions, with some consideration to the transportation requirements for health services. The other areas are assumed to remain at sea and are not considered.

B.   METHODOLOGY

This analysis is broken into two main components: the determination of support requirements and an analysis of the ability to satisfy those requirements. Chapter III deals with the determination of requirements, and has three steps:

- Identification of the forces to be supported.

- Identification of the supporting assets and their characteristics.

- Determination of support requirements based on this information.

Chapter IV details the supportability analysis, which has two steps:

- Determine the maximum distance at which assets can satisfy force delivery and support requirements.

- Assess the effects of aircraft attrition on maximum support distance.

III. DETERMINATION OF REQUIREMENTS

A.   IDENTIFY FORCES TO BE SUPPORTED

The Marine Corps deploys its combat assets as a MAGTF, a combined arms force consisting of a Command Element (CE), an Air Combat Element (ACE), a Ground Combat Element (GCE), and a Combat Service Support Element (CSSE). A Marine Expeditionary Unit, Special Operations Capable (MEU(SOC)) is the smallest MAGTF, with the following typical composition:

- CE - Has detachments of the following:
  Force Reconnaissance Company
  Radio Battalion
  Air and Naval Gunfire Liaison Company (ANGLICO)
  Communications Battalion
  Intelligence Company

- ACE - A reinforced helicopter squadron and a Marine Air Control Group detachment consisting of:
  12 CH-46E medium lift helicopters
  4 CH-53E heavy lift helicopters
  3 UH-1N light utility helicopters
  4 AH-1W light attack helicopters
  6 AV-8B VTOL fixed-wing light attack aircraft
  2 KC-130 tankers (on standby in CONUS)
  5+ Stinger missile teams

- GCE - A Battalion Landing Team (BLT) consisting of a reinforced infantry battalion:
  3 Rifle Companies
  1 Weapons Company
  1 Artillery Battery with six M198 155mm Howitzers
  1 Light Armored Reconnaissance Platoon with seven LAVs
  1 Assault Amphibian Platoon with 12 AAVs
  1 Combat Engineer Platoon.

B. IDENTIFY SUPPORTING ASSETS

1. Shipping

A MEU(SOC) deploys embarked on an Amphibious Ready Group (ARG). An ARG may have three to four ships, but usually consists of an LHD or LHA, an LPD, and an LSD. Table 1 summarizes the Landing Craft-Air Cushion (LCAC) and aircraft capacities of these ships (Betaque, 1995).

Ship	Number of Aircraft*	Number of LCACs
LHD	45	3
LHA	42	1
LPD-17	6	2
LSD-41	0	4
LSD-49	0	2

* CH-46 equivalents

Table 1. ARG component LCAC/aircraft capacities

The LHA or LHD is the primary aviation ship and carries the Command Element of the MEU. The LPD has both a well deck and limited aircraft capability. LPD-17 is currently under development. It will be more survivable and stealthy than current amphibious ships and will be the best suited member of the ARG to come in close to shore, if needed. The LSD is primarily a well-deck ship. All of the ships will carry some components of the embarked MEU(SOC).

2. Aircraft

The medium-lift aircraft in 2010-2015 will be the MV-22 tiltrotor. It replaces the CH-46E and CH-53D. It doubles the speed of the CH-46 and quadruples the range. The MV-22 has an internal capacity of 10,000 pounds at a radius of up to 500 NM (Turley, 1989). While the MV-22 has a substantial external lift capability (15,000 lbs. vs. 4,000 lbs. for the CH-46E), it comes at the expense of speed. The MV-22 cruises at 240 knots with an internally carried load, while external load operations require an airspeed of 150 knots or less.[1]

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[1]This is not due to the flight characteristics of the MV-22, but of the external load.

The USMC heavy lift helicopter is the CH-53E. With an external load capacity of 32,000 lbs., it is the only helicopter that can transport the LAV or the M198 155 mm howitzer. The CH-53E can also provide a forward refueling capability using the Tactical Bulk Fuel Delivery System, CH-53E (TBFDS, CH-53E). This is a quick install and uninstall fueling system which is carried internally. It can provide up to 2,400 gallons of fuel and has the necessary fueling equipment to act as a forward refueling site for aircraft or land vehicles (U.S. Marine Corps, 1997). Table 2 summarizes the characteristics of the MV-22 and CH-53E.

Aircraft Type	Radius (NM)	Internal Load Airspeed (Kts)	External Load Airspeed (Kts)	Troops	Payload (pounds)	Average Availability	Spot Factor
MV-22	500	240	150	24	15,000	85 %	1.7
CH-53E	250	150	130	55	32,000	60 %	2.5

Table 2. Aircraft Characteristics[2]

The projected ACE composition for 2010-2015 has the CH-46Es replaced one-for-one by MV-22s. This results in a footprint of 48 CH-46E-equivalent spots. This equals the maximum spots available in an LHA-based ARG, and only leaves three extra spots in an LHD-based ARG.

3.   Surface

The LCAC is designed primarily to carry wheeled or tracked vehicles, artillery, and heavy equipment. It can carry up to 60 tons at more than 40 kts, and has a range of 300 NM at 35 kts (Naval Surface Warfare Center, 1997). Although highly mobile, the LCAC is fairly large and is unarmored. It would be difficult to use in the face of a defending force, and would generally come ashore after the Advanced Amphibious Assault Vehicles (AAAVs). An ARG will have six to eight LCACs

The AAAV will enter service around 2006. It replaces the AAV7A1, and offers a greatly increased capability. It will travel over water at 25 kts vs. 6-8 kts, providing a truly over-the-horizon capability. Over land it will move at more than 45 kts, which will allow as

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[2]The information in this table was compiled from a number of sources: Magwood, Lyons, and Nance 1995, Turley 1989, and Morgan 1996.

much mobility as the M1A1 tank. The AAAV will carry 18 fully-equipped Marines or up to 5,000 pounds of cargo, and will be armed with a 25 mm Bushmaster gun and a 7.62 mm machine gun (General Dynamics Land Systems, 1997). A typical MEU will have twelve AAAVs (Ashinhurst, 1997).

4. New Technologies

The Guided Parafoil Air Delivery System (GPADS) is a GPS-guided Parafoil capable of delivering loads of up to 42,000 pounds from altitudes of up to 25,000 feet. The parafoil has a 2.5 to one glide ratio to allow up to 12 miles of offset from the delivering aircraft (Kean, 1995). Smaller versions of this could be deployed from the MV-22.

The Semi-Rigid Glider is a semi-rigid deployable wing and has been field tested by the CWL. The system resembles a hang glider and has a 30' wingspan. Weighing 1,200 pounds, it can carry a payload of 500 pounds out to 20 NM from its launch point. Using GPS, it is accurate to within 100 meters (Evans, 1996). This system would allow some degree of stealth to the supported unit and also put the delivering aircraft at less risk. This system, as well as the GPADS, would allow resupply in weather precluding landing or direct ground delivery.

C. DETERMINE SUPPORT REQUIREMENTS

1. Force Mixes

For a MEU(SOC) conducting OMFTS, three schemes of employment are analyzed, two using STOM and one using the Sea Dragon concept of RAPs.

a. STOM Air and Sea Mix

The first is an Air- and Sea-borne assault. The air component consists of two of the Battalion Landing Team's three rifle companies inserted by MV-22. The sea component consists of a Light Armored Reconnaissance platoon deployed by LCAC, and an AAAV platoon deployed directly from the ARG, carrying the remaining rifle company. The rifle companies would each be augmented by two Weapons Company HMMWVs, inserted by air.

A notional deployment scheme for this mix would have the main body of the ARG close to 40 NM offshore to deploy LCACs and aircraft, while an LPD came to 25 NM

to deploy the AAAVs. Once surface units had been deployed and LCACs recovered, the ARG could withdraw to 50 NM or more offshore, possibly leaving an LPD or other flight deck capable ship to act as a Forward Arming and Refueling Point (FARP). The artillery battery would remain at sea, to be inserted and extracted by CH-53E for raids as needed. Implicit in this type of operation is that there would be no CSS area established at a beachhead. Because of this, the of the LCACs' heavy lift capacity could be used to move forces ashore, but not for the sustainment of those forces once deployed. Substantially all sustainment would be delivered by air. In addition, since two of the rifle companies are foot mobile only, there is a requirement for enough airlift to move at least one company up to 25 NM per day. The daily support requirements of this force would be for the sustainment of the three individual rifle companies and the two armored units, and sufficient troop lift to move one of the rifle companies up to 25 NM (Blasiol, 1997).

The high speed and mobility of the AAAV will see AAAV employments that resemble helicopter operations. FARPs will support AAAVs as well as helicopters (Ashinhurst, 1997). The scheme is for a MEU(SOC)s Battalion Landing Team, and for this force size, FARPs and other CSS areas will not be based ashore. Sustainment for AAAVs and LAVs will be delivered directly to the units, and aircraft fuel and ammunition support will come from the LHA or LHD, or from a sea-based FARP, such as an LPD brought closer to shore than the main body of the ARG.

b. STOM Air Mix

The second scheme is an entirely air-inserted assault. The three rifle companies are inserted by air, with no mechanized component or HMMWVs. This scheme could be driven by lack of safe surface delivery routes, or an objective requiring too great a standoff from the beach. As in the first scheme, artillery would remain at sea and be delivered by CH-53E on demand. The support requirements for this force would be to sustain the three individual companies and provide airlift to move at least two of them per day.

c. *Sea Dragon RAP Mix*

The third case is the most drastic departure from traditional operations and makes most use of the new Sea Dragon concepts. In this case the BLT organization would consist of 27 reconnaissance assault platoons and a mobile combined arms company (MCAC), made up of LAVs, AAAVs, and HMMWVs, as required. The RAPs are squad-sized units which would engage critical targets with remote fires. Fires could come in the form of naval surface fire support, close air support, or artillery raids. Nine of these units would be ashore at any time, with the remainder either preparing for insertion or recovering from the field. The MCAC would remain at sea and come ashore as needed, then quickly return to the ARG. The support requirements for this force assume that each of the nine teams will require one MV-22 movement or resupply action daily.[3]

2. Calculation of Requirements

The supply requirements of each unit are for Class I (Food and Water), Class III (Petroleum, Oil, and Lubricants), and Class V (Ammunition). Class I (Food) is based on three Meals, Ready-to-eat (MREs) per Marine per day, weighing 1.46 pounds per MRE. Class I (Water) is based on five gallons per Marine per day. Requirements for Classes III and V are obtained from the AAAV program office and a Center for Naval Analyses study, *Project CULEBRA: Sea-Based Combat Service Support for Ship-to-Objective Maneuver (Supply and Transportation Analysis)*. Table 3 summarizes the supply requirements for each of the GCE components (Adapted from Magwood, Lyons, and Nance, 1995 and Ashinhurst, 1997).

D. SPECIFY HOW SUPPORT ASSETS WILL BE USED

1. MV-22

As the medium-lift replacement aircraft, the MV-22's primary mission will be the movement and sustainment of troops. The preferred method used to resupply units in the field is to carry cargo externally, which allows for easy pickup and drop-off, and minimizes

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[3]Note that this is a conservative estimate of RAP support requirements. These units are expected to be capable of operations for several days without resupply. Also, in some scenarios, some aircraft could resupply more than one unit per sortie.

Unit	People	Class I (Food)	Class I (Water)	Class III (POL)	Class V	Total Weight
Rifle Company	182	806	7,644 (910 gal.)	230 (30 gal.)*	842	9,292 9,522*
LAR Platoon	35	154	1,470 (175 gal.)	3,430 (490 gal.)	2,243	7,297
AAAV Platoon	47	205	1,974 (235 gal.)	14,280 (2,040 gal.)	3,259	19,718
RAP	13	57	546 (65 gal.)	0	60**	663

* For Rifle Company augmented with two Weapons Company HMMWVs.
**At Rifle Company rates. RAPs, as envisioned, would avoid direct combat.

Table 3. Daily sustainment requirements of MEU(SOC) GCE units (in pounds)

the time the aircraft is at risk to enemy fire. While this requires that the aircraft fly slower than it could without an external load, in the past the added time was usually offset by the speed of loading and unloading. For the MV-22, however, the speed penalty for external loads is much larger (90 knots vs. 20 knots for the CH-53E). Unfortunately, unless materiel handling equipment or a large landing zone is available, large internal loads are time consuming to unload. In this analysis, only the small cargoes for the Sea Dragon RAPs are treated as internal payloads. All others are external loads. [4] Food, water, and ammunition are packaged on pallets, and fuel is transported in 500 gallon bladders, which the MV-22 can carry two of at one time.

Deception is a significant component of OMFTS (U.S. Marine Corps, 1996). In addition to the required sustainment and troop movement missions, MV-22s will also be used for decoy missions to deceive the enemy. This analysis looks at two cases: zero deception missions and one deception mission for every three actual missions.

2.   CH-53E

Due to the small number (4-8) of CH-53Es and their relatively low operational availability (~60%), they would be dedicated to providing mobility to the artillery battery and any emergent heavy lift requirements (e.g., recovery of an LAV). Although the TBFDS,

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[4]As a sensitivity analysis, supportability calculations were also performed using all sustainment except fuel transported internally. The results differred by less than 6%. While internally loaded cargo is preferred, it does not appear to be a driver for the forces analyzed.

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CH-53E provides a forward refueling capability, it is not considered in this analysis due to the requirement for artillery movement.

3.   Daily Lift Requirements

Tables 4 and 5 show the insertion and daily sustainment requirements for each of the force mixes. In the first three mixes, a minimum of two aircraft are required per mission. It is coincidental, but fortuitous, that the insertion and sustainment requirements are so similar. The extra two sorties required to insert the Air mix have a negligible effect on the results of the analysis.

Force Mix	Internal Cargo	External Cargo	Troop Movement	Deception	Total Sorties
Air/Sea 3 Rifle Companies 1 AAAV Platoon 1 LAR Platoon	0	4	16	8	28
Air 3 Rifle Companies	0	0	24	8	32
Sea Dragon 9 RAPs (Two aircraft/mission)	0	0	18	6	24
Sea Dragon 9 RAPs (One aircraft/mission)	0	0	9	3	12

Table 4. Day 1 MV-22 sortie requirements for insertion of MEU(SOC) force mixes

Force Mix	Internal Cargo	External Cargo	Troop Movement	Deception	Total Sorties
Air/Sea 3 Rifle Companies 1 AAAV Platoon 1 LAR Platoon	0	10	10	8	28
Air 3 Rifle Companies	0	6	16	8	30
Sea Dragon 9 RAPs (Two aircraft/mission)	0	0	18 (includes resupply)	6	24
Sea Dragon 9 RAPs (One aircraft/mission)	0	0	9 (includes resupply)	3	12

Table 5. Daily MV-22 sortie requirements of MEU(SOC) force mixes

IV. SUPPORTABILITY ANALYSIS

A. DETERMINE MAXIMUM DISTANCE AT WHICH ASSETS CAN SATISFY SUPPORT REQUIREMENTS

1. Equations

This section describes the formulas used to calculate the maximum separation distance between units ashore and the sea-based sources of logistical support. The basic equation to determine this distance is

$$D = \frac{(H-T) \times V}{S} \qquad (1)$$

where D ≡ round trip distance in nautical miles,

H ≡ operational aircraft hours per day,

T ≡ total unusable time (on deck, loading, unloading, or refueling) in hours,

V ≡ aircraft speed in knots,

S ≡ number of sorties (Edwards 1993, 173).

The following equations are used to take into account differing sortie types, times, and airspeeds:

Number of available aircraft (N_A):

$$N_A = (N \times A_O) - N_R \qquad (2)$$

where N ≡ total number of a type of aircraft,

A_O ≡ average operational availability of aircraft type,

N_R ≡ number of aircraft held in reserve.

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Number of sorties required per aircraft per day (S):

$$S = \frac{S_I + S_E + S_M + S_D}{N_A} (RoundedUp) \tag{3}$$

where S_I = total number of internal load sustainment sorties per day,

S_E = total number of external load sustainment sorties per day,

S_M = total number of troop movement sorties per day,

S_D = total number of deception sorties per day.

(Rounding up prevents an aircraft from flying a fractional sortie.)

Total number of sorties required per day (S_T):

$$S_T = S \times N_A \tag{4}$$

Extra time required for particular missions:

Additional time per external load sortie (T_E), assuming one-way transport of external load:

$$T_E = \frac{D}{2V_E} - \frac{D}{2V_I} = \frac{D}{2} \times (\frac{1}{V_E} - \frac{1}{V_I}) \tag{5}$$

where D = round trip distance per sortie,

V_E = aircraft speed with an external load,

V_I = aircraft speed with an internal load.

Additional time per troop movement sortie (T_M):

$$T_M = \frac{D_M}{V_I}$$
(6)

where $D_M \equiv$ average distance to transport troops.

Total time spent on deck plus additional time spent on troop movement and external cargo transport for all aircraft (T_T):

$$T_T = (T_D \times S_T) + (T_M \times S_M) + (T_E \times S_E)$$
(7)

where $T_D \equiv$ Average on-deck time per sortie.

Total operational aircraft hours per day (H_T).

$$H_T = H \times N_A$$
(8)

where $H \equiv$ operational hours per aircraft per day.

To integrate the above equations, we start with the equation for round-trip distance per sortie (D):

$$D = \frac{(H_T - T_T) \times V_I}{S_T}$$
(9)

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Expanding T_T gives

$$D = \frac{(H_T - (T_D \times S_T) - (T_M \times S_M) - (T_E \times S_E)) \times V_I}{S_T} \tag{10}$$

Expanding T_E gives

$$D = \frac{(H_T - (T_D \times S_T) - (T_M \times S_M)) \times V_I - \frac{D}{2} \times (\frac{1}{V_E} - \frac{1}{V_I}) \times S_E \times V_I}{S_T} \tag{11}$$

Reducing this gives

$$D = \frac{(H_T - (T_D \times S_T) - (T_M \times S_M)) \times V_I}{S_T} - \frac{\frac{D}{2} \times S_E \times (\frac{V_I}{V_E} - 1)}{S_T} \tag{12}$$

Moving all D terms to the left side of the equation gives

$$D \times (1 + \frac{1}{2} \times \frac{S_E}{S_T} \times (\frac{V_I}{V_E} - 1)) = \frac{(H_T - (T_D \times S_T) - (T_M \times S_M)) \times V_I}{S_T} \tag{13}$$

Solving for D gives

$$D = \frac{(H_T - (T_D \times S_T) - (T_M \times S_M)) \times V_I}{S_T + \frac{S_E}{2} \times (\frac{V_I}{V_E} - 1)} \tag{14}$$

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The final step is to solve for the effective one-way distance from ship to supported unit:

$$D^* = (\frac{D}{2}) \times E \tag{15}$$

where E ≡ Percentage of range that is effectively used. This allows for range reduction due to different ingress/egress routes, flight paths to avoid air defenses, and any other necessary maneuvering.

2. Inputs

This analysis uses the following as baseline inputs to the above equations, including some variations:

- N_A = 12 MV-22s. Present plans are to replace the CH-46E one-for-one on the LHDs and LHAs.

- A_O = 0.85. This is the anticipated operational availability for the MV-22 (Morgan 1996).

- N_R = 0, 2. At present, most MEU(SOC) operations do not hold back any aircraft for contingency missions, such as Tactical Recovery of Aircraft and Personnel (TRAP), MEDEVAC, or emergency extraction of ground combat units. A section (usually two aircraft) is designated as the TRAP section, but will go about normal operations until a mission requirement arises. The distances involved in OMFTS, the lack of ground transport or facilities for casualty evacuation and treatment, and the vulnerability of dispersed, small units provide some justification for a dedicated, on-call section for emergent missions.[5] This analysis looks at both cases, 0 and 2.

- S_I, S_E, and S_M are self-explanatory.

- S_D = 0, $(S_I + S_E + S_M)/3$. OMFTS, especially the dispersed unit concept, advocates the use of deception and feints. This analysis looks at two cases. The first has no deception missions, as a baseline, and the second has one deception mission flown for every three real sustainment or troop movement sorties.

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[5]In Vietnam, 8-10% of small reconnaissance patrols required some form of emergency extraction (West 1996).

- $T_D = 30$ minutes. The expected operational refueling time for the MV-22 is 10-15 minutes. External load pickup or release is approximately one minute. Internal cargo times vary, but can range from five to 30 minutes. Troop loading and unloading is approximately two minutes. We assume a notional 30 minute on-deck time for turn around.

- H = eight hours per day per aircraft. This is a limit based primarily on the aircrew maximum flight hours, but also reflects aircraft maintenance requirements.

- $E = 80\%$. From interviews with Marine helicopter pilots, this figure was considered a fair estimate of the amount of range lost due to flight path routing.

3. Baseline Results

Table 6 summarizes the results for the different force mixes. The distance shown is the total separation distance possible between supporting ships and supported units. Three cases are looked at for each mix: using all available aircraft for troop movement and sustainment; holding two aircraft in reserve for TRAP or MEDEVAC; and adding deception missions while holding two aircraft in reserve. Note that these figures assume a permissive air defense environment.

B. ASSESS EFFECTS OF AIRCRAFT ATTRITION ON MAXIMUM SUPPORT DISTANCE

1. Approach

The preceding section provides the maximum separation from sea base to ground units in a permissive air environment. To examine the impact of a non-permissive environment and the effects of aircraft attrition, a circulation model is used, shown in Figure 1.

Force Mix		Distance (NM)
Air/Sea 3 Rifle Companies AAAV platoon LAR platoon	Using all available aircraft	289
	Holding 2 aircraft in reserve	182
	2 reserve + 1 deception / 3 actual missions	129
Air 3 Rifle Companies	Using all available aircraft	192
	Holding 2 aircraft in reserve	188
	2 reserve + 1 deception / 3 actual missions	132
Sea Dragon 9 RAPs (Two aircraft/mission)	Using all available aircraft	327
	Holding 2 aircraft in reserve	201
	2 reserve + 1 deception / 3 actual missions	201
Sea Dragon 9 RAPs (One aircraft/mission)	Using all available aircraft	711*
	Holding 2 aircraft in reserve	331
	2 reserve + 1 deception / 3 actual missions	331

* Distances > 500 NM require aerial refueling

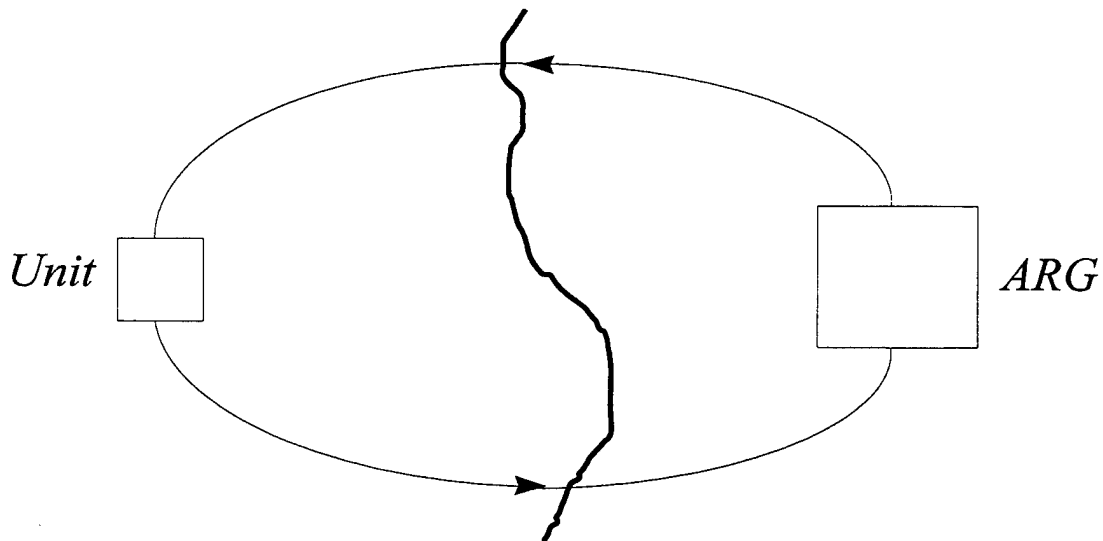**Table 6. Supportable ship/unit ranges in a permissive air environment**

Figure 1. Circulation Model

2. Equations

The following assumptions are made:

- There is a fixed probability of an aircraft being shot down for every 100 NM flown *over land*, and the probability does not change with distance or time, i.e., the probability is the same crossing the beach as it is 200 NM inland, and is the same on D+1 as it is on D+15.

- Extra missions required to recover downed aircrew are not taken into account.

- The MEU(SOC) operation will not fundamentally change as a result of aircraft losses.

- Aircraft losses are binomially distributed (ie., independent and identically distributed)[6] with parameters n and p_S, where

  $n \equiv$ Total number of aircraft sorties per day, and

  $p_S \equiv$ probability of shootdown per sortie.

$$p_S = 1 - (1 - p)^{D_s} \tag{16}$$

where p $\equiv$ Probability of shootdown per 100 NM traveled over land, and is assumed to be .01.

$D_S \equiv$ Average distance flown over land per sortie (100s of NM). Fractional values of D_S are used when appropriate.

The expected losses of all operating aircraft for the above equation each day are

$$E[AircraftLosses] = np_S \tag{17}$$

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[6]Thus the effects of "hot spots" of air defenses, operational attrition due to sandstorms, torrential rain, snowstorms and the like are disregarded, although in such cases p_S tends to be higher than "on the average."

The expected losses are calculated for the end of each day, and the number of aircraft available for the following day is decreased by this amount. This may be a fractional number of aircraft because it is the *expected* number of aircraft remaining. The distance calculations in the previous section are recomputed based on this number and the new maximum separation distance determined. Figure 2 shows the decrease in operating distance as aircraft losses increase.
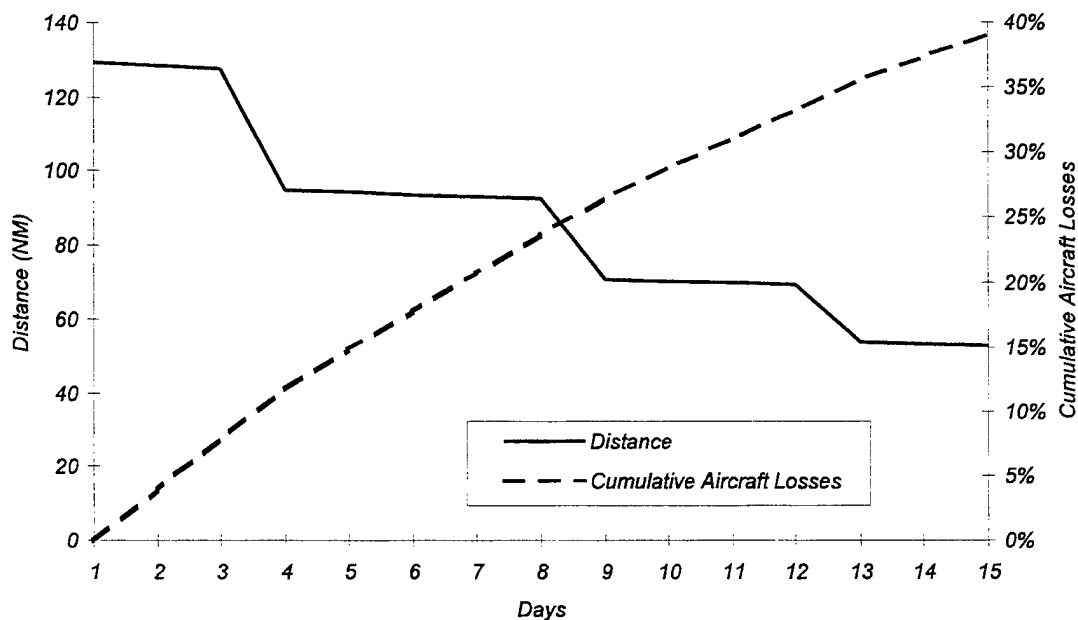

Figure 2. Maximum Supportable Range in a Non-Permissive Environment (Air/Sea Force Mix Variation 3)

3. Results

Table 7 summarizes the supportable distances for the different force mixes at day one, seven, and fifteen of an operation.

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Force Mix		Distance (NM) Day		
		1	7	15
Air/Sea 3 Rifle Companies AAAV platoon LAR platoon	Using all available aircraft	296	184	93
	Holding 2 aircraft in reserve	186	127	69
	2 reserve + 1 deception / 3 actual missions	131	95	54
Air 3 Rifle Companies	Using all available aircraft	203	138	99
	Holding 2 aircraft in reserve	201	137	73
	2 reserve + 1 deception / 3 actual missions	139	75	43
Sea Dragon 9 RAPs (Two aircraft/mission)	Using all available aircraft	327	200	98
	Holding 2 aircraft in reserve	201	136	72
	2 reserve + 1 deception / 3 actual missions	201	99	55
Sea Dragon 9 RAPs (One aircraft/mission)	Using all available aircraft	711*	330	327
	Holding 2 aircraft in reserve	331	329	200
	2 reserve + 1 deception / 3 actual missions	331	203	138

* Distances > 500 NM require aerial refueling

Table 7. Supportable ship/unit ranges in a non-permissive air environment

4.   An Example from the OMFTS Concept Paper

The OMFTS concept paper gives an example of a hypothetical amphibious force conducting STOM against the eastern seaboard of the United States. Based on 24 hours of maneuvering at sea, the amphibious force requires the U.S. to defend the beaches from Charleston, South Carolina, to New Jersey. Richmond, Virginia, is selected as the objective and the force attacks the city directly from the sea (U.S. Marine Corps, 1996).

From the preceding calculations, Richmond, at 95 NM inland, would require the ARG to stay within 45 NM of the Delaware/Maryland/Virginia coastline to conduct STOM, while Sea Dragon units could be inserted from a distance of more than 100 NM at sea. These distances apply only for a permissive air environment. In a non-permissive air environment, neither of the STOM force mixes could even be supported from the beach itself after one week of operations. The only force mix that could be sustained in this environment is the Sea Dragon mix, and then only if the units are supported by individual aircraft instead

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of flights of two. To support this mix for an additional week would require the supporting ships to close from 100+ NM from the beach to within 43 NM.

V. CONCLUSIONS

A.   SUMMARY OF RESULTS

OMFTS, as envisioned, precludes surface resupply. Surface resupply over land requires secure land lines of communication and ground transportation. The distances involved require defense of these lines of communication, just as a beach CSS area would. CSS must be provided by air. In this thesis we have measured the outer limits of airborne CSS of a MEU(SOC) based on the airlift assets in a future MEU as it is now planned with twelve MV-22s. CH-53Es will be used for heavy lift support, including vehicles and artillery, in special circumstances. LCACs and AAAVs will be used for the delivery of equipment and Marines only - not sustainment.

When OMFTS is conducted using traditional forces (without artillery permanently ashore, moving troops by air and surface means and sustaining troops, LAVs, and AAAVs), the envisioned amphibious ship standoff of 50+ NM is difficult if employing any deception missions or holding any aircraft in reserve, and is not possible in a non-permissive air environment.

Shifting to a non-mechanized force does not ease the problem because of the increased airborne troop movement requirements.

Shifting to the use of RAPs helps somewhat. However, the current practice of sending a two-aircraft section severely limits the possible range capability, because their payload is so light. If only one aircraft is sent to resupply or move a team, there is a huge increase in range. After 7 days of attrition (and the loss of 1/4 of the aircraft) it is still possible to conduct operations more than 200 NM from the ship. But, this decreases to 138 NM by day 15.

B.   RECOMMENDATIONS

Increased capability could be achieved by a number of different measures:

- Increase ACE aircrews. This would allow more than eight hours per day aircraft utilization. However it is not certain how this would affect the operational availability of the aircraft or whether more severe maintenance requirements would result.

- Increase the number of MV-22s in the ACE. Making use of the spots on the LPD would allow 3 additional aircraft. Replacing the UH-1s with an additional MV-22 would increase lift capacity, at the cost of not having a light helicopter capability. While not as valuable in OMFTS as the MV-22, the UH-1 is still a useful aircraft for sustained operations ashore or operations other than war.

- If a MEU is to sustain OMFTS operations for more than a week, anticipate the need to replenish the ACE with additional MV-22s.

- Small units could be supported at greater distances if one MV-22 was sent on each mission instead of the two-plane section that is the standard for helicopter operations today. The analysis shows that two-plane sections suffer a particularly onerous penalty in range because of their light load.

This thesis considers an amphibious ready group operating independently of a carrier battle group (CVBG). A CVBG, whether part of a Naval Expeditionary Force or not, would:

- Reduce attrition to MV-22s by providing escort or suppression of enemy air defenses.

- Provide some additional lift or reserve lift capability if some MV-22s were assigned to the CV.

To realize the full value of OMFTS, there must be a shift to more lethal forces with smaller logistical demands, or a sizable increase in airlift capability. To maintain a safe standoff from shore, maintain operational flexibility, and still support OMFTS, the Navy will need to push development of inshore combat tactics through means similar to those undertaken by the Commandant's Warfighting Lab. Influencing events ashore is more than being able to strike deep inland with precision weapons and aircraft. It is the ability to affect the campaign deep inland with forces on the ground. Until a lighter, more lethal Marine force is feasible, the Navy should plan on providing support to Marines from close to shore.

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